

# **GUIDESHEET I**

## **HYDROGEOLOGIC STUDY REQUIREMENTS**

Rule 2221 of the Part 22 Rules of Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, requires that before obtaining a discharge permit authorized under R323.2218, an applicant shall provide a hydrogeologic report that meets the requirements of this rule.

The hydrogeologic study should:

- 1) Describe the regional hydrogeologic conditions.
- 2) Identify whether the discharge will occur within a designated wellhead protection area.
- 3) Determine whether the discharge is to a usable aquifer, an unusable aquifer, or groundwater not in an aquifer.
- 4) Define the areal and vertical extent and physical properties of the site earth materials that assimilate and transmit the discharge.
- 5) Provide sufficient information to propose a groundwater monitoring program to measure compliance with Part 22 standards.

The information required in a hydrogeologic study is very technical and can be extremely complex. It is therefore strongly recommended that the applicant consider the following. First, they should hire professionals with a background in the field of hydrogeology, preferably those that have some familiarity with the groundwater discharge permit program. And second, they should request that their consultant provide a hydrogeologic study workplan, in accordance with Rule 2221(3), for review and approval to the Groundwater Permits Unit, Permits Section, Water Bureau, P.O. Box 30273, Lansing, MI 48909-7773 prior to commencing any fieldwork. Approval of a workplan does not mean an applicant will be guaranteed approval of their authorization application. It does insure that the location and scope of work will meet the expectations of Rules, and reduce or eliminate the need for multiple iterations of the same hydrogeologic study.

**A Hydrogeologic Report shall contain the following elements in order to meet the requirements of Rule 2221 of the Part 22 rules of Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451**

**NARRATIVE**

The narrative portion of the hydrogeologic report shall contain the following:

- \_\_\_ Historical land use of the site.
- \_\_\_ Land use in the vicinity of the site.
- \_\_\_ Regional geology.
- \_\_\_ Surface waters and drainage patterns in the area.
- \_\_\_ Is discharge located within a designated wellhead protection area?
- \_\_\_ Purpose of the hydrogeologic study.
- \_\_\_ Discussion of field activities.
- \_\_\_ Conclusions relative to the hydrogeologic conditions of the site and acceptability of the discharge.

Recommendations as to the following:

- \_\_\_ Additional hydrogeologic investigation.
- \_\_\_ Upgrade of wastewater treatment system.
- \_\_\_ Modifications to disposal method.

**CHARACTERIZATION OF SITE EARTH MATERIALS**

The site earth materials shall be characterized by the following field activities:

- \_\_\_ A minimum of 5 soil borings for a 5 acre site and 3 soil borings for each additional 5 acres.
- \_\_\_ Soil borings shall be of sufficient depth to characterize site earth materials that assimilate and transmit the discharge.
- \_\_\_ Soil samples shall be collected by standard soil sampling techniques.
- \_\_\_ The particle size distribution, by both sieve and hydrometer.
- \_\_\_ The classification under the unified soil classification system, under ASTM D2487-93.
- \_\_\_ Vertical Permeability.
- \_\_\_ Phosphorus adsorption capacity.

## **GROUNDWATER CHARACTERIZATION**

Groundwater conditions beneath the site must be characterized by determining the following:

- \_\_\_ Depth to groundwater.
- \_\_\_ Thickness of saturated formation.
- \_\_\_ Direction of groundwater flow, both vertical and horizontal.
- \_\_\_ Velocity of groundwater flow.
- \_\_\_ Interconnection of groundwater formations.
- \_\_\_ Venting locations of groundwater to surface water.
- \_\_\_ Background groundwater quality.
- \_\_\_ Existing groundwater quality.
- \_\_\_ Groundwater mounding calculations.

## **GROUNDWATER MONITORING**

The following should be included to address groundwater monitoring:

- \_\_\_ Proposal for a groundwater monitoring program to be incorporated into the groundwater discharge permit.
- \_\_\_ A sampling and analysis plan.

## **TABLES**

Soil boring and well information:

- \_\_\_ Top of casing elevation.
- \_\_\_ Ground elevation.
- \_\_\_ Depth to groundwater.
- \_\_\_ Static water elevation.
- \_\_\_ Depth and elevation of screened interval.
- \_\_\_ Elevations should be referenced to USGS datum.
- \_\_\_ Groundwater and Effluent quality data.
- \_\_\_ Hydraulic Conductivity test results.
- \_\_\_ Phosphorus Adsorption Capacity test results.
- \_\_\_ Vertical permeability test results.

## **MAPS**

- \_\_\_ Regional Topography Map with property boundaries of site location
- \_\_\_ Residential well log map. The map shall include the locations of residential wells within ½ mile of the discharge location. The residential well locations should be cross-referenced to well logs submitted as part of the hydrogeologic report.
- \_\_\_ Site map. The site map shall include the following:
  - \_\_\_ Property boundaries.
  - \_\_\_ Soil boring and well locations.
  - \_\_\_ Wastewater treatment facility and discharge location.
  - \_\_\_ Surface waters, including wetlands.
  - \_\_\_ Groundwater contours with the maximum contour interval being 1 ft.
  - \_\_\_ Geologic cross sections generated from soil borings and wells at the site.

## **CALCULATIONS**

Appendixes should be included which contain calculations for each of the following:

- \_\_\_ Groundwater flow direction.
- \_\_\_ Horizontal and vertical hydraulic gradient of aquifer.
- \_\_\_ Vertical and horizontal hydraulic conductivity data.
- \_\_\_ Groundwater flow velocity.
- \_\_\_ Groundwater mounding.
- \_\_\_ Phosphorus adsorption capacity of soils.
- \_\_\_ Nutrient uptake of cover crop.

## **RAW DATA**

The following raw data should be included in each hydrogeologic report:

- \_\_\_ Soil boring logs.
- \_\_\_ Monitor well logs.
- \_\_\_ Domestic well logs within ½ mile of the discharge.
- \_\_\_ Laboratory data sheets for groundwater and effluent quality sampling.
- \_\_\_ Soil size gradation data.
- \_\_\_ Hydraulic conductivity data.

## **CHARACTERIZATION OF SITE EARTH MATERIALS**

### **Drilling Method**

The drilling method used should be capable of clearly identifying the horizon from which samples are collected, and allow collection of undisturbed samples, if necessary. Examples of acceptable drilling methods include Hollow Stem Augers (ASTM D1452), cable tool, and the use of a Geoprobe. Mud rotary and solid core augers are not acceptable drilling methods.

### **Soil Borings**

A minimum of five soil borings for the first five acres, and three soil borings for each additional five acres or portion thereof. The total number of soil borings required will depend on the complexity of the site geology. At each boring, collect a sample from each soil layer or change in lithology. Acceptable soil sampling techniques include Split Spoon sampling (ASTM D1586), and Shelby Tube sampling (ASTM D1587).

Two of the five initial borings should be logged using continuous sampling methods. For sites larger than five acres, one of each of the three additional borings should be logged using continuous sampling methods. All elevation data collected (ground, water level, and depth of boring) should be corrected to USGS datum.

All soil borings not converted to observation wells should be backfilled, plugged and recorded according to approved procedures provided in part 127 of Act 368 of the Public Acts of 1978, as amended. You may also use the Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities (ASTM D5299-92), or other Department approved methods.

### **Soil Testing**

Soils testing should be performed on samples collected from each soil layer or change in lithology. These tests include, but are not limited to particle size distribution by sieve and/or hydrometer, unified soil system classification as per ASTM D2487-69, and the Standard Penetration Test (ASTM D1586-84).

In addition, you will need to provide testing of the unsaturated zone sufficient to determine the ability of site earth materials to percolate and transmit the volume of liquids resulting from the discharge, and the vertical and horizontal extent of mounding resulting from the discharge. Tests to make these determinations include the triaxial cell method (EPA document "Soil Properties, Classification, and Hydraulic Conductivity Testing"), the constant head method (ASTM D2434-68), or a Department approved in-situ field method.

## **GROUNDWATER CHARACTERIZATION**

### **MONITOR WELL INSTALLATION**

#### **Casing Materials**

The selection of appropriate materials for monitoring well casing must take into account several site specific factors including: 1) geologic environment, 2) natural geochemical environment, 3) anticipated well depth, 4) types and concentrations of discharge parameters, and 5) design life of the monitoring well. Materials that

are commonly used for monitoring wells in this program are PVC, galvanized and stainless steel.

### **Well Diameter**

The diameter of the casing for a monitoring well is generally selected to accommodate downhole equipment. Additional casing diameter selection criteria include: 1) drilling or well installation method used, 2) anticipated depth of the well and associated strength requirements, 3) ease of well development, 4) volume of water required to be purged prior to sampling, and 5) rate of recovery of the well after purging. Generally, a 2-inch inside diameter well casing is acceptable.

### **Screen Size and Length**

The screen design must accommodate varying physical and chemical characteristics. Screens with the following characteristics provide the best service in most geological conditions. 1) Slot openings should be continuous around the circumference of the screen, permitting maximum accessibility to the aquifer so that efficient development is possible. 2) Slot openings should be spaced to provide maximum open area consistent with strength requirements to take advantage of the aquifer hydraulic conductivity. 3) Screens must be sufficiently strong to withstand stresses normally encountered during and after installation. In addition, the slot size of the well screen should be determined relative to the grain size analysis of the stratum interval to be monitored and the gradation of the filter pack material. This is most commonly done with a sieve analysis. In most circumstances, the use of a 10-slot well screen is acceptable.

Screen length should be adequate to supply enough water to obtain a representative sample. However, it should not be of such length that a diluted sample is collected. It should be noted that screening over much of the aquifer thickness could contribute to vertical movement of the parameters of concern. A screen length of three to five feet is appropriate in most cases.

### **Well Screen Packing**

Once the well is in place, the screen should be surrounded by materials that are coarser; have a uniform grain size; and have a higher permeability than natural formation material. This allows groundwater to flow freely into the well from the adjacent formation material while minimizing or eliminating the entrance of fine-grained materials.

These purposes can be accomplished by designing the well in such a way that either the natural coarse-grained formation materials or artificially introduced coarse-grained materials, in conjunction with appropriately sized well screen openings, retain the fine materials outside the well while permitting water to enter. Thus, there are two types of wells and well intake designs; naturally developed wells and wells with an artificially introduced filter pack.

In natural development, a highly permeable zone is created around the screen from materials existing in the formation (see discussion below). In filter packing, a specially graded sand or gravel having high porosity and permeability is placed in the annulus between the screen and the natural formation.

### **Annular Seals**

Any annular space that is produced as the result of the installation of well casing in a borehole provides a channel for vertical movement of water and/or contaminants unless the space is sealed. The seal serves several purposes:

1) to provide protection against infiltration of surface water and potential contaminants, 2) to seal off discrete sampling zones, and 3) to prohibit vertical migration of water.

The annular seal in a monitoring well is placed above the filter pack in the annulus between the borehole and the well casing. The annular seal may be comprised of several different types of permanent, stable, low-permeability materials including pelletized, granular or powdered bentonite, neat cement grout and combinations of both (ASTM D5092-90).

### **Surface Completion and Protective Measures**

Two types of surface completions are common for groundwater monitoring wells:

1) aboveground completion and 2) flush-to-ground surface completion. An aboveground completion is preferred whenever practical. The primary purposes of either type of completion are to prevent surface runoff from entering and infiltration down the annulus of the well and to protect the well from accidental damage or vandalism.

Whichever type of completion is selected for a well, there should always be a surface seal of neat cement or concrete surrounding the well casing and filling the annular space between the casing and the borehole at the surface.

A protective casing is generally installed around the well casing by placing the protective casing into the cement surface seal while it is still wet and uncured. The protective casing discourages unauthorized entry into the well and prevents damage by contact with vehicles. This outer casing should be kept locked between sampling events. Like the inner well casing, the outer protective casing should be vented near the top to prevent the accumulation and entrapment of potentially explosive gases and to allow water levels in the well to respond naturally to barometric pressure changes.

### **Well Development**

Well development has two broad objectives: 1) repair damage done to the formation by the drilling operation so that the natural hydraulic properties are restored, and 2) alter the basic physical characteristics of the aquifer near the borehole so that water will flow more freely to the well. All new wells should be

developed before being put into use. In addition, older wells often require periodic redevelopment.

Effective development procedures should cause reversals of flow through the screen openings that will agitate the sediment, remove the finer fraction, and then rearrange the remaining formation particles. Examples of methods that apply this principal are backwashing and mechanical surging. Using a bailer or one directional pumping to develop a well is not acceptable.

## **AQUIFER TESTING**

### **Water Level Measurement**

The basic water level measuring device is a steel tape typically coated with ordinary carpenter's chalk. This is the simplest water level measuring device. Other water level measuring devices include pressure transducers and electric sensors. Pressure transducers are suspended in the well on a cable and measure height of water above the transducer center. Electric sensors are suspended on the end of a marked cable. When the sensor encounters conductive fluid, the circuit is completed and an audible or visual signal is displayed at the surface. All measurements should be related to a known USGS datum, which should be measured from a clearly identified location on each casing.

### **Horizontal Hydraulic Conductivity**

In order to determine the horizontal hydraulic conductivity of the aquifer, either a pump test or a slug injection or recovery test will need to be performed. Pumping tests are typically performed in wells with a high transmissivity and in wells with a diameter large enough to accommodate the pumping equipment. Nearby observation wells are generally required to measure aquifer response. Conversely, slug injection or recovery tests, that add or remove smaller amounts of water, are typically performed in formations with low transmissivity and in a single, smaller diameter well.

### **Groundwater Sampling**

Sampling of monitoring wells should generally be done by field personnel from the testing laboratory or by groundwater professionals. In general, a sample is taken only after the pH, electrical conductivity, and temperature of the water being pumped from the well has stabilized. The methodology used in the sampling procedure is critically important if the true chemical nature of the groundwater at the site is to be determined. Samples may not be representative of groundwater conditions for the following reasons:

1. The sample was taken from stagnant water in the well, which is usually different chemically from the water in the ground near the well bore.
2. The water sample was contaminated by entrained sediment because the well was not developed properly.

3. The sample was taken so long after pumping began that it represents water far enough from the well site that the groundwater chemistry is not representative.
4. Release of carbon dioxide during pumping caused an increase in pH, which in turn caused many metallic ions to come out of solution.
5. Numerous chemical changes took place because the sample was oxidized during recovery.
6. Chemical residues in the pump or sampling equipment contaminated the water sample.
7. The sample was not preserved correctly, so chemical changes occurred in the sample during storage.

A wide variety of groundwater sampling devices are available to meet the requirements of a groundwater-monitoring program. The method used should be tailored to fit the chemicals being monitored, the hydrogeologic situation, and the design of the monitoring wells. It is strongly recommended that samples be collected with either a bladder or a peristaltic pump. Bladder pumps are positive-displacement devices that use a pulse of gas to push the sample to the surface. The gas does not come into contact with the sample and positive pressure is maintained at all times. A peristaltic pump draws fluid into the pump by a tube trapped between two rollers. It is the complete occlusion of the tube that makes this pump a positive displacement pump, preventing backflow and eliminating the need for check-valves when the pump is stationary. If another method is chosen to collect groundwater samples, you will need to demonstrate how you will collect representative samples from the wells.

### **Filtration and Preservation**

For filtering dissolved inorganic samples, a 0.45 micron filter pore size should be used. Flush or rinse filter membranes and sample containers with laboratory grade water before use unless the equipment is already pre-washed and rinsed. In addition, discard the first 150 milliliters of sample that passes through the filter before filling sample containers. Use positive pressure filtration rather than vacuum filtration, which causes excessive aeration and agitation of the samples.

Preserving samples retards biodegradation reactions, hydrolysis reaction, precipitation and coprecipitation reactions and sorption reactions. Sample preservation usually involves reducing or increasing pH by adding an acid or base preservative. Samples are also preserved by cooling them to 4°C. Add preservative to the container before or immediately after collecting the sample. If a sample requires filtration, add preservative after filtration, not before.

### **Venting Demonstration**

Rule 2222 (7)(b)(i) states that the Department may approve a standard different from the standards established in subrules (2) and (6) of this rule when a demonstration is made that the groundwater affected by the discharge vents to

surface water, uses of the surface water are protected in accordance with R323.1041 to R323.1117, and the distance between the point of discharge and the point of venting to surface water is less than 1000 feet. This demonstration will need to be included within the hydrogeologic investigation report. The demonstration can be accomplished using one of the following methods:

1. Using cluster wells placed as close as possible to the surface water body, collect static water elevations and determine the vertical gradient of the aquifer. Well locations will need to be along the entire length of the proposed venting location at approved spacing.
2. Place a minimum of three monitoring wells on both sides of the surface water body, and collect static water elevations. Groundwater flow maps can then be generated showing groundwater flow direction.
3. Provide soil boring and cross-sectional data showing that the aquifer is of limited vertical extent, and that the surface water bottom is at or near the regional aquitard.

Methods using static water elevations will also need to show that venting occurs throughout the year, and is not just a seasonal artifact.

### **ESTABLISHING BACKGROUND GROUNDWATER QUALITY**

Rule 2222 (5) (a) and Rule 2222 (7) (c) (I) of the Part 22 Rules of Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, limits inorganic substances not described in subrule (2) (a) or (b) or (c) of this rule by the following criteria:

The concentration of the inorganic substance in groundwater shall not exceed a concentration  $\frac{1}{2}$  way between the background groundwater quality and the concentration at which the site would be a facility as defined by part 201.

The inorganic substance limit established in a permit shall be determined by one of the following methods:

1. The concentration that is  $\frac{1}{2}$  way between background groundwater quality and the concentration at which the site would be a facility as defined by part 201.
2. The applicant may choose a default background groundwater quality value, which is the limit of detection as established by the State Environmental Laboratory, and have a permit limit  $\frac{1}{2}$  way between the limit of detection and the concentration at which the site would be a facility as defined by part 201.

If the applicant chooses to establish a site specific background groundwater quality value, background shall be determined by the following method:

A well or wells approved by the Waste Management Division shall be sampled for the parameters of concern at least every other month for one year. Two replicate samples shall be obtained for each sampling event. The arithmetic mean concentrations shall then be calculated. The background groundwater quality shall be calculated as the arithmetic mean plus one standard deviation.

## **HYDROGEOLOGIC STUDY REQUIREMENTS APPLICATIONS FOR GROUNDWATER PERMIT REISSUANCE**

### **1. NARRATIVE**

The narrative portion of the hydrogeologic study for a reissuance application must include a discussion of the groundwater and effluent compliance history of the facility. The applicant should summarize the effluent and groundwater quality results during the previous permitted time interval, and indicate whether compliance was achieved during that time. If there were exceedances of permit limits, steps taken to bring the facility into compliance should be described.

This portion should also include a discussion of the groundwater monitoring system. Groundwater contour maps generated during the timeframe of the permit should be reviewed, and a determination made whether the groundwater monitoring system is appropriate. If there are indications that, as a result of mounding or other factors, the groundwater flow direction has changed, a proposal and workplan for an updated groundwater monitoring system should be included.

The narrative should also discuss whether changes from the original permit application and issuance have occurred. This should include the volume of treated wastewater discharged, the treatment system used to meet permit limits, addition of waste streams or changes in wastewater influent quality, and methods and areas of disposal.

### **2. MAPS**

Updated site map, indicating the location of the treatment/storage facilities, discharge scaled location(s), observation and monitor wells, property boundaries and surface waters within the area of the map.

Updated groundwater contour map, which indicates the location of all wells used to establish groundwater flow direction. This map should be generated using the most recent static water levels measured in all wells at the facility. Static water levels measured in each well must be collected on the same date.

### **3. RAW DATA**

The most recent groundwater monitoring results from all monitoring wells.

The most recent effluent quality results.

The most recent static water levels and groundwater elevations from all on site monitoring wells.